sPHENIX Hadronic Calorimeter Tile Light Response Simulation

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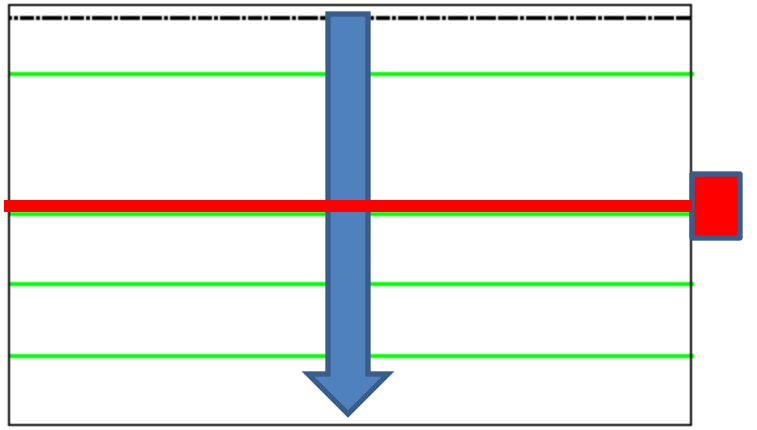
Input Measurement:

Small control panel, flash LED (very collimated) and measure SiPM light output as a function of the distance away from the fiber. LED flashed through white coating and on the non-fiber side.



Signal falls off almost exponentially with the distance from the fiber

Exp(-Δx / 2.3 cm)

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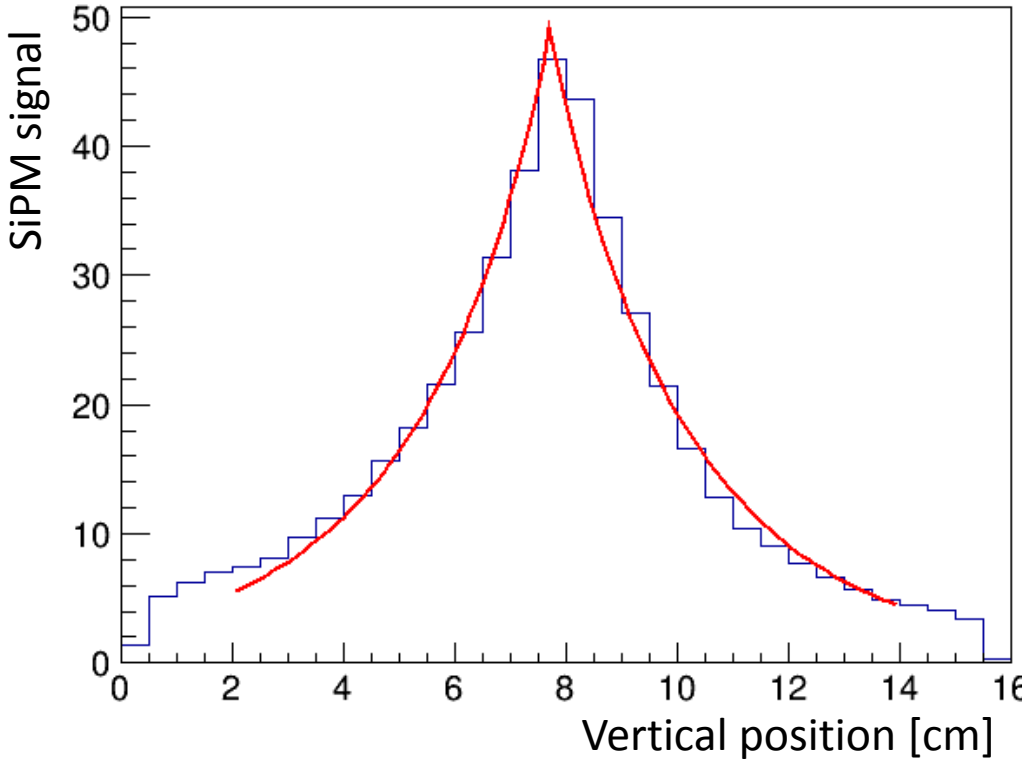
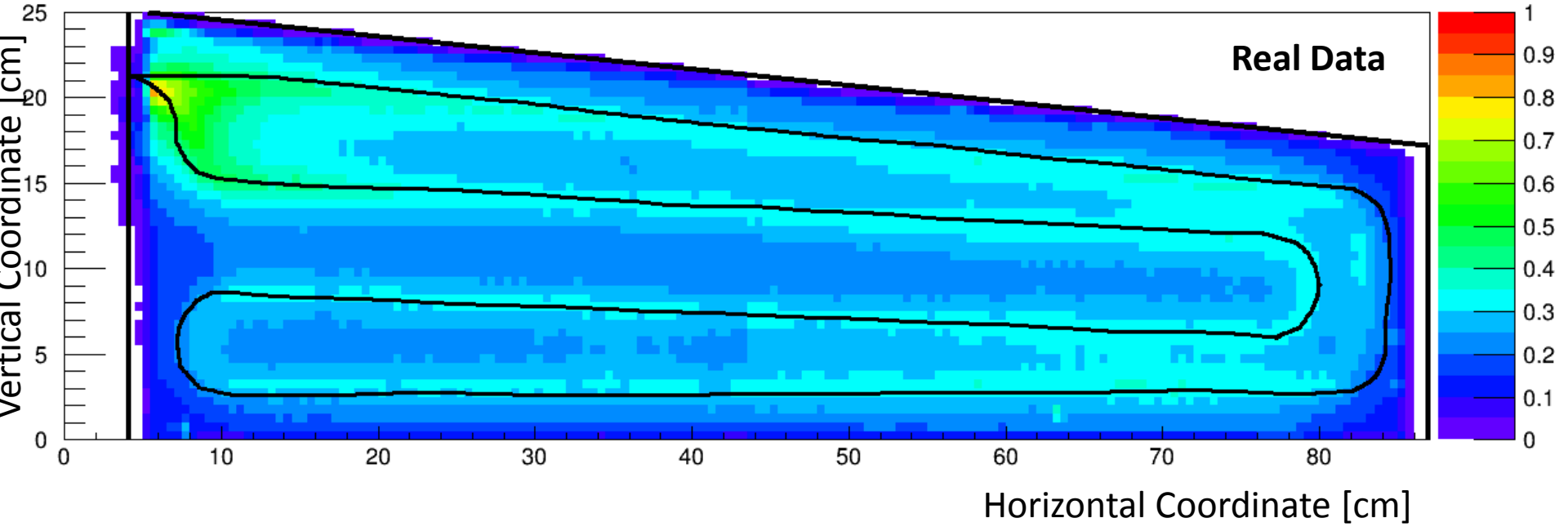
 KEY: TF1      gengaus;1       [0]*TMath::Exp(-pow(TMath::Abs(x-[1]),[3])/[2])
root [15] hmiddle->Fit("gengaus","R","",2.0,14.0);
 FCN=2.46818 FROM MIGRAD    STATUS=CONVERGED      53 CALLS          54 TOTAL
                     EDM=2.39942e-08    STRATEGY= 1      ERROR MATRIX ACCURATE
  EXT PARAMETER                                   STEP         FIRST
  NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
   1  p0           4.94691e+01   6.63256e+00   2.13384e-03  -8.81113e-07
   2  p1           7.70893e+00   1.19300e-01   1.05029e-04  -4.49295e-04
   3  p2           2.29852e+00   7.26957e-01   1.00866e-04   9.62716e-04
   4  p3           9.31331e-01   1.76221e-01   3.30634e-05  -3.14084e-03
```

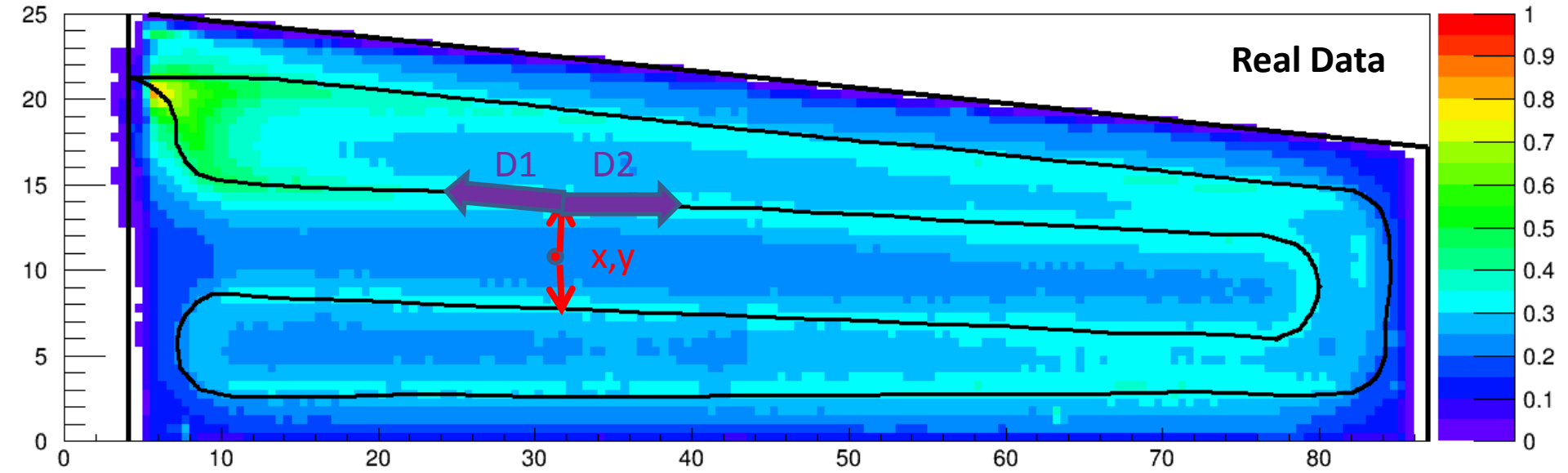


Identical setup LED scan of large tile relative light signal.
Again flashed through the white coating on the non-fiber side.



Can we re-produce this relative light yield with a simple model?

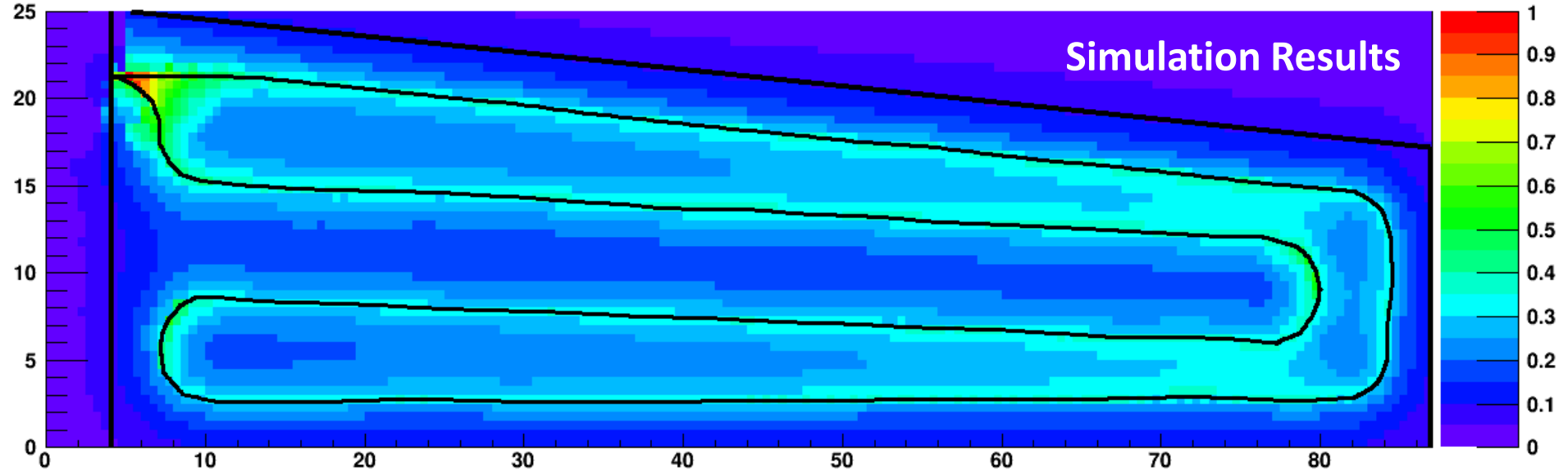
We could then use that model to optimize the design and also make a more general input map for different tiles in simulation.

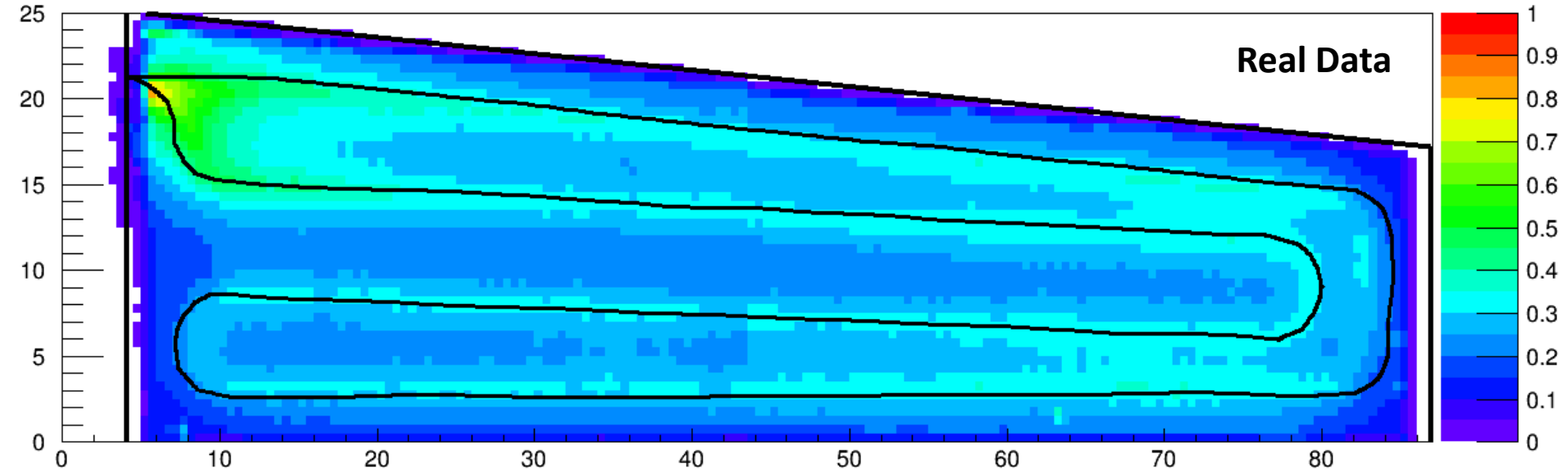


For each position (x,y) on the scintillator…

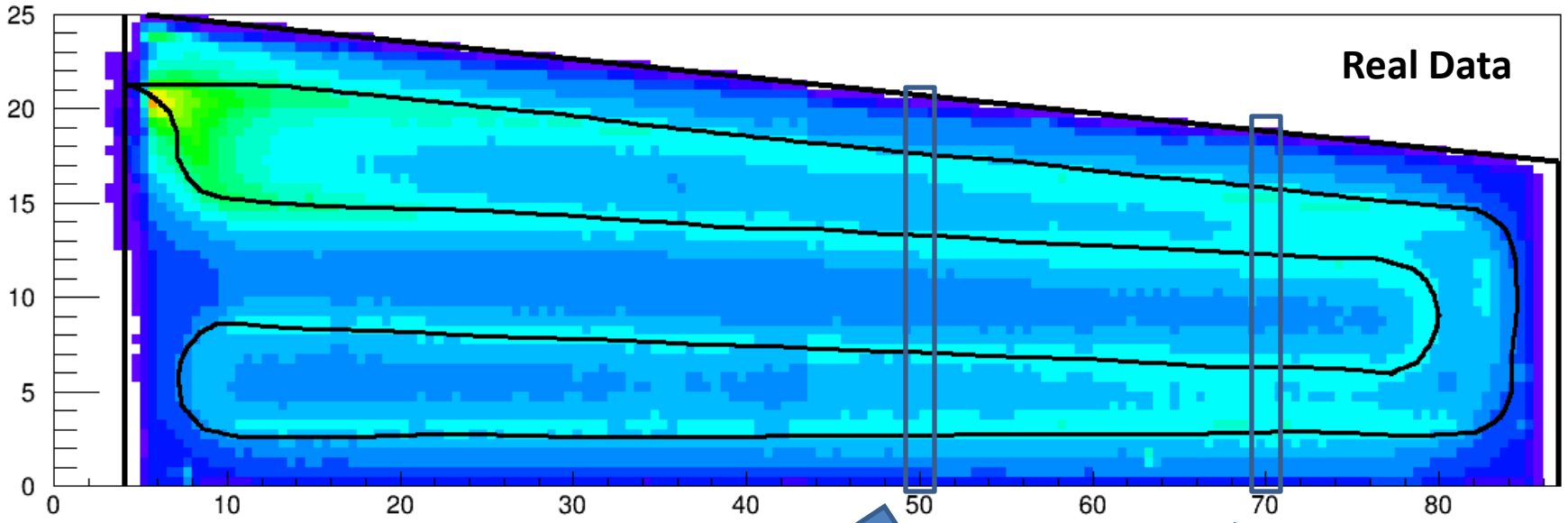
- Determine (1) the shortest distance to the fiber and (2) the second shortest distance to the fiber requiring them to be on different segments.
- Determine from the Exponential parameterization the relative light signal deposited in the fiber.
- For both (1) and (2) calculate the distances D1 and D2 in both directions along the fiber to the SiPM readout.
- Calculate the attenuation of the signal assuming 50% of the light in the core with λ=350 cm and 50% in the cladding with λ=5 cm

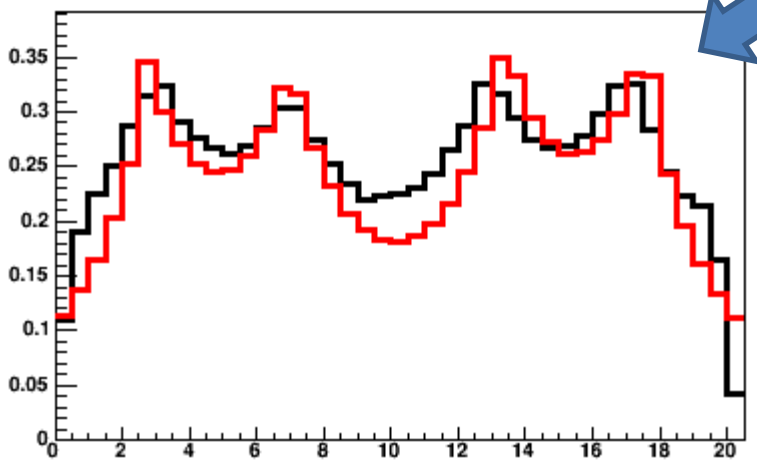
Simulation Calculation yields a full position dependent light map

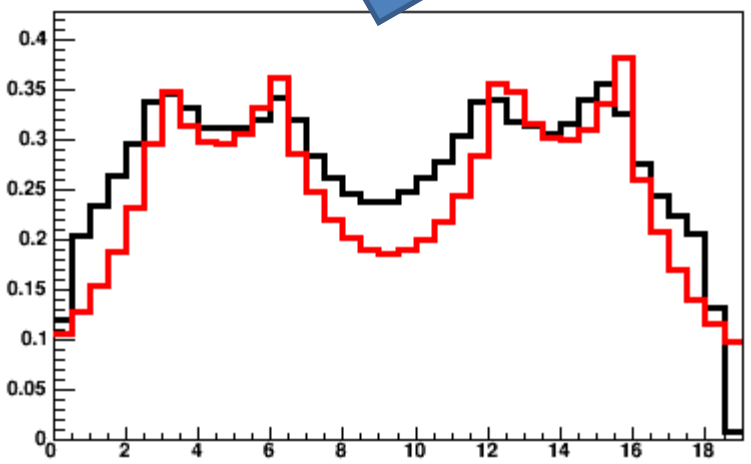




Reasonable qualitative agreement, though simulation looks sharper.

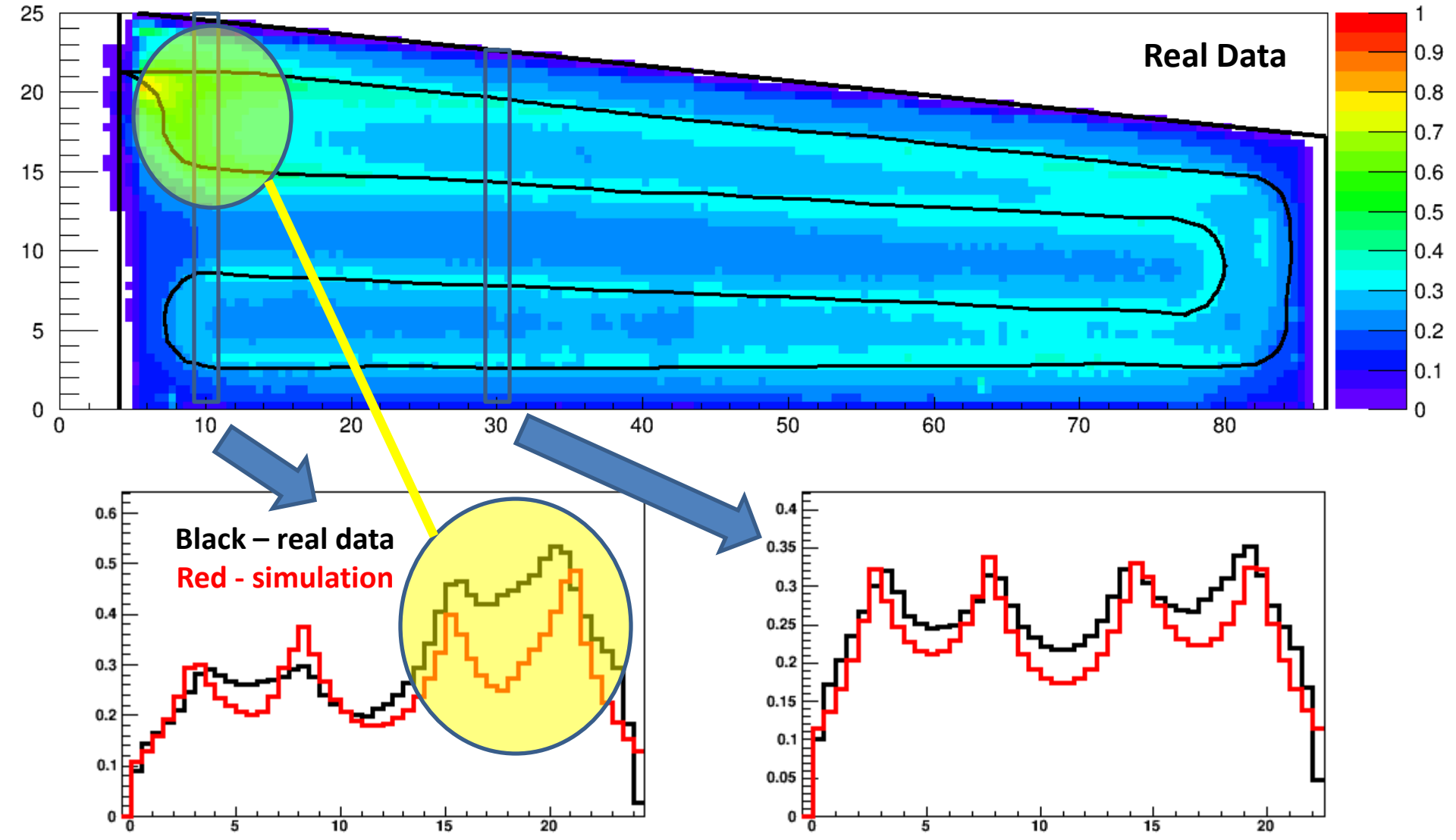






Black – real data

Red - simulation



Reasonable agreement overall.
Drop-off away from fibers is stronger in simulation – i.e. sharper peaks and valleys.
Not as strong a signal enhancement right near the SiPM readout –
cladding light modeling not quite right, direct light, other (?)

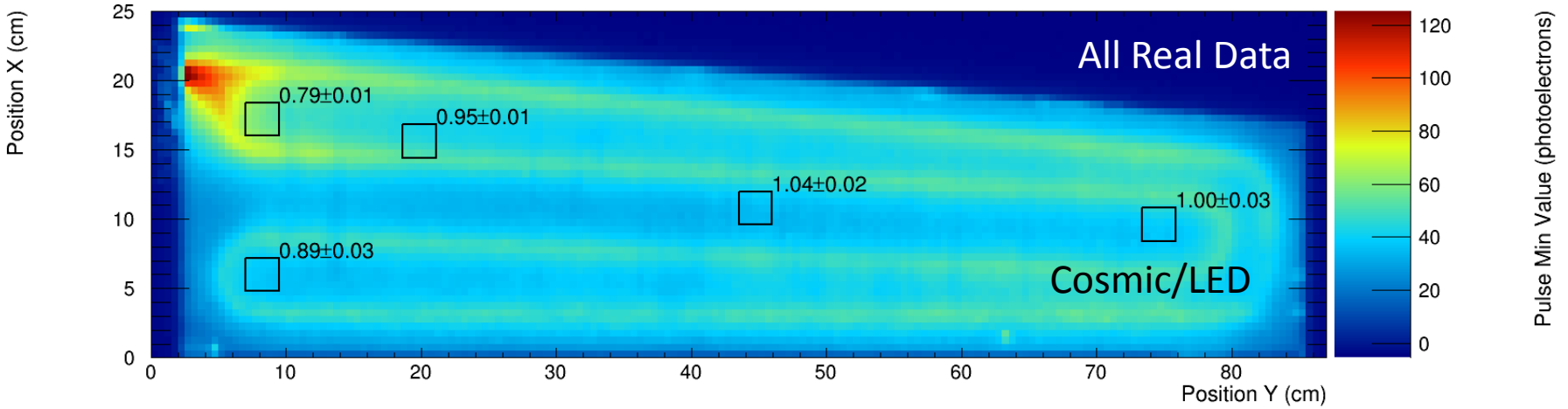
Concern – does the LED light entering the panel really serve as a good proxy for ionization in the scintillator at that position?

Very sharp light response when LED flashed through white coating on non-fiber side could be due to direct light capture. Then perhaps we do not want to optimize on that model.

Next slide shows comparison of LED light map and cosmic data – but the cosmic trigger cannot have same level of position precision.

What more can we do here in Colorado on this front…

Comparing 5 cosmic test results on MIP signal with LED scan. Note that cosmic trigger is about 2.5 cm x 2.5 cm.



The values are the ratios of (cosmic signal / LED signal) at that position. It is arbitrarily normalized to give 1.00 for the right most box.

Ideally if cosmic and LED response is similar, all values are near one. Most significant deviation is -20% lower signal for cosmics near SiPM readout. Note that this could also partially be from slight misalignment (i.e. could the trigger have been slights to the right and thus have a lower signal).

Not possible due to 2.5 cm x 2.5 cm and 8 hour test time to compare much more differentially.